THE SOCRATES$^{2.0}$ PILOT IN CITY OF COPENHAGEN

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ADDRESS
Technolution
Burgemeester Jamessingel 1
2803 WV Gouda

CONTACT PERSON
Jan Romijnders
Pilot Site leader Copenhagen
Phone +31 648127185
Email: jan.romijnders@
technolution.nl

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Colophon

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Created by	Jan Romijnders
Reviewed by	Edwin Mein, Art Feitsma, Lukasz Kosma, Tiffany Vlemmings, Giovanni Huisken
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1. INTRODUCTION

In Activity 3 the functional design of the use cases Optimising Network Traffic Flow (ONTF), Quality of Environment (QoE) and Smart Destination (SD) has been described and approved by the SOCRATES2.0 steering group in October 2018. In Activity 5 this functional design is elaborated in more detailed designs. Based on this latter design the pilot is developed and executed.

This document presents the functional and technical designs of the Socrates$^{2.0}$ use cases 'Optimising Network Traffic Flow', 'Quality of Environment' and 'Smart Destination' in the pilot site Copenhagen. It is a report on the technical designs and the changes made on the traffic centre, the realization of intermediaries, the changes on back offices, the end-user applications, the system integrations tests, the operational period and is the final report.

The technical architecture of the above mentioned Use Cases includes sequence diagrams, user stories and interface descriptions. These are elaborated for each cooperation model, based on the functional designs as described in Activity 3.

2. INTRODUCTION – OPTIMISING NETWORK TRAFFIC FLOW & QUALITY OF ENVIRONMENT

As the use cases ONTF and QoE are linked closely together those use cases are documented in the same chapter.

2.1 Use case description – Optimising Network Traffic Flow & Quality of Environment

Coming from the policy goals to turn Copenhagen into a Carbon Neutral City by 2025, the pilot in Copenhagen focuses on a multi-modal interactive traffic management approach including the integration of multimodal services. The ultimate challenge for the pilot site is to find an approach where interactive traffic management with various data and service providers can indeed improve the level of service.

For ONTF and QoE the goal is to incorporate multiple modalities (cars & cyclists) and optimise the traffic flow based on the policy goals of the city of Copenhagen. This means that cycling is a priority over car traffic in the city centre. However, the cars are facilitated in the ring around the city centre. This is depicted in the different networks as shown in figure 1 and 2:

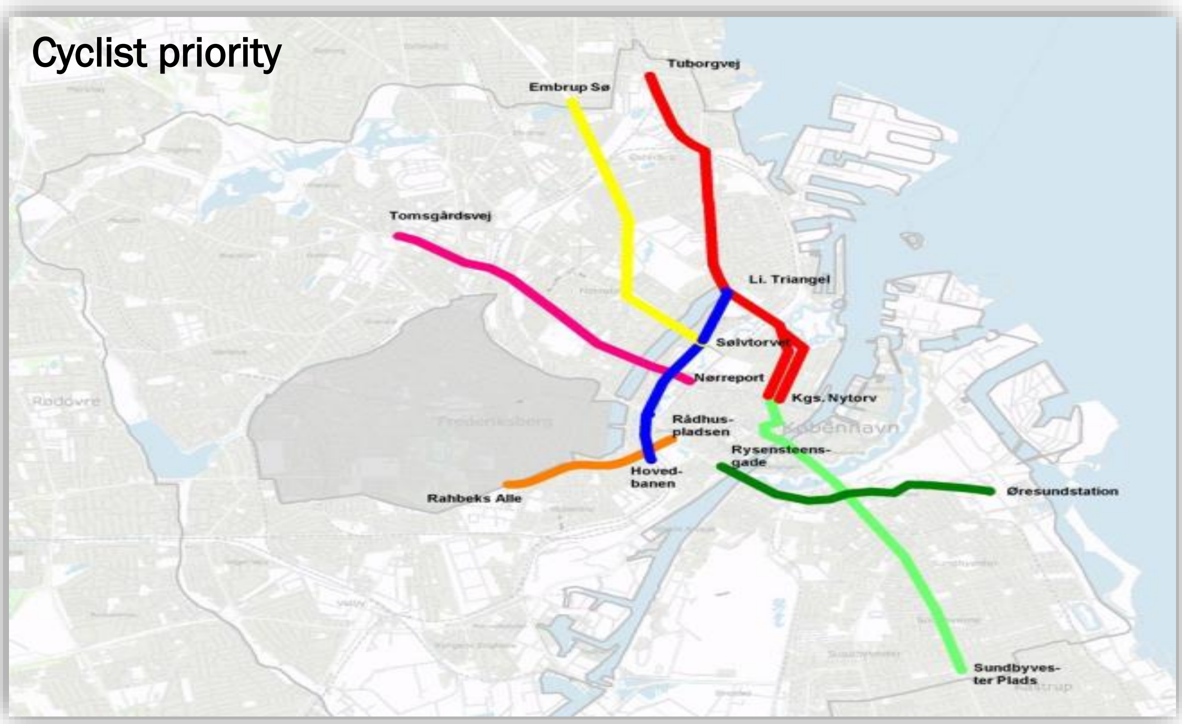


FIGURE 1 - CYCLIST PRIORITY NETWORK COPENHAGEN

FIGURE 2 - CAR PRIORITY NETWORK COPENHAGEN

The network is divided in several links. A link is a one-directional connection between two decisions points. On a decision point the driver does make a choice about the next link in its route.

For each link, the relative speed is monitored. When there is too much traffic, the relative speed will drop, and finally it will fall due to a traffic jam. By monitoring the relative speed and calculating the Level of Service, it is possible to detect the traffic state which can be transformed into a 'problem state'. This is the trigger to start network management activities.

Quality of Environment

Next to the car and cycling networks, there are also areas indicated for the Quality of Environment use case. See the maps underneath. The areas are based on the locations of the air quality sensors.

FIGURE 4 - GEOFENCE AIR QUALITY SENSOR 1

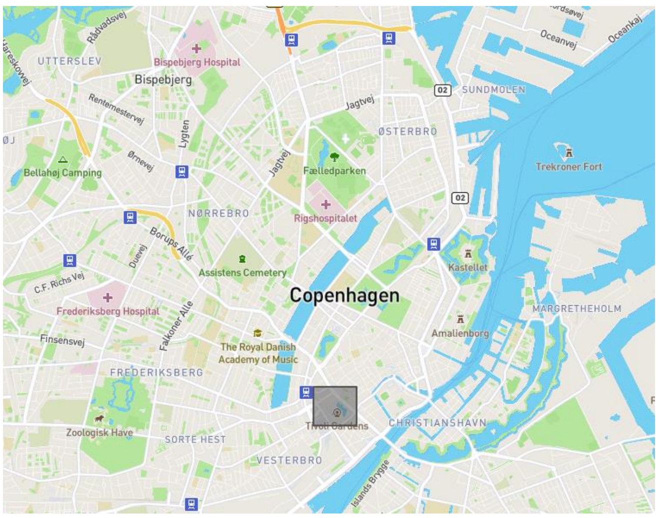


FIGURE 3 - GEOFENCE AIR QUALITY SENSOR 2

2.2 Active partners & roles

FIGURE 5 – ACTIVE PARTNERS AND ROLES IN THE COPENHAGEN ONTF & QOE USE CASE

Partner	Role in use case
City of Copenhagen	Road Authority and data provider
Technolution	Network Monitor & Network Manager
TomTom	Data provider / End user Service provider

City of Copenhagen (Road authority)

The road authority for the city of Copenhagen. They are consulted for their strategies and tactics for traffic management and they allowed the connection between the Network Monitor and their traffic management platform MobiMaestro so that the ViSense cycling data could be used.

Technolution (Network Monitor and Network Manager)

Technolution has the lead for the pilot site and facilitates the Network Monitor and the Network Manager.

TomTom (Data provider & End user service provider)

TomTom acts as both a data provider as well as an end user service provider where they guide their users via an app away from the requested avoided road/areas initiated by the Network Manager.

2.3 Functional overview

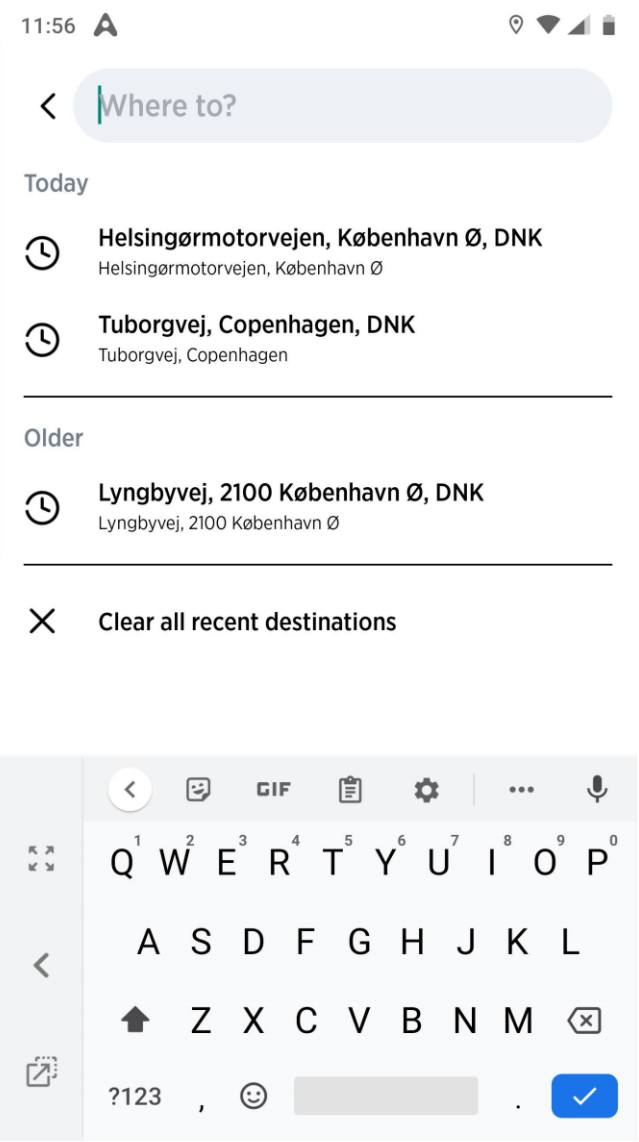
Changes in relation to Activity 3 – functional design

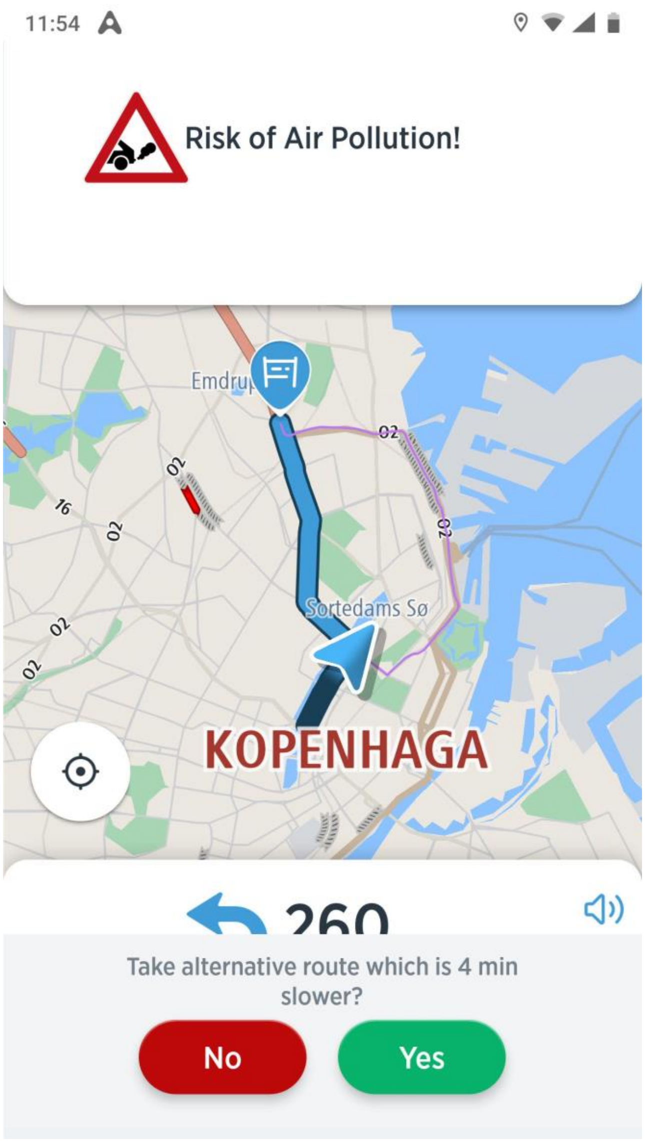
The table below contains an overview of the changes made during the further development of the Use Case in Activity 5, in relation to the Activity 3 functional design. All the things that have not changed are not documented in this table.

	SOLL	IST
	Geofence is activated/deactivated based on (expected) traffic and derived from that data a higher anticipated pollution	Air quality is measured through air quality sensors and based on that information a geofence is activated/deactivated.
Intermediary	City of Copenhagen acts as intermediary	City of Copenhagen was not an intermediary. Technolution took over that role.
Pre-/post conditions		Conditions still apply.
Sequence diagram		See changes in figure 6

2.4 Generic description of end user service

TomTom deployed an Android app where Turn by Turn navigation is incorporated based on their navigation engine. Additional features for that app, incorporated because of SOCRATES2.0, are that users are asked to avoid a certain road because there is more traffic on that road then is efficient for the overall car network which can cause delays. Next to that, car users are asked to avoid a road if more cyclist are detected by the bicycle sensors then the predetermined threshold. In that way space is given to the cyclist and creates a safer environment. These advices from TomTom to their users are based on the requests that the Network Manager sends out.
The same can happen for the Quality of Environment. Then the end user is asked to avoid an entire area. The end user is informed that the advice is based on poor air quality. In both cases TomTom provides an alternative route for the end user.





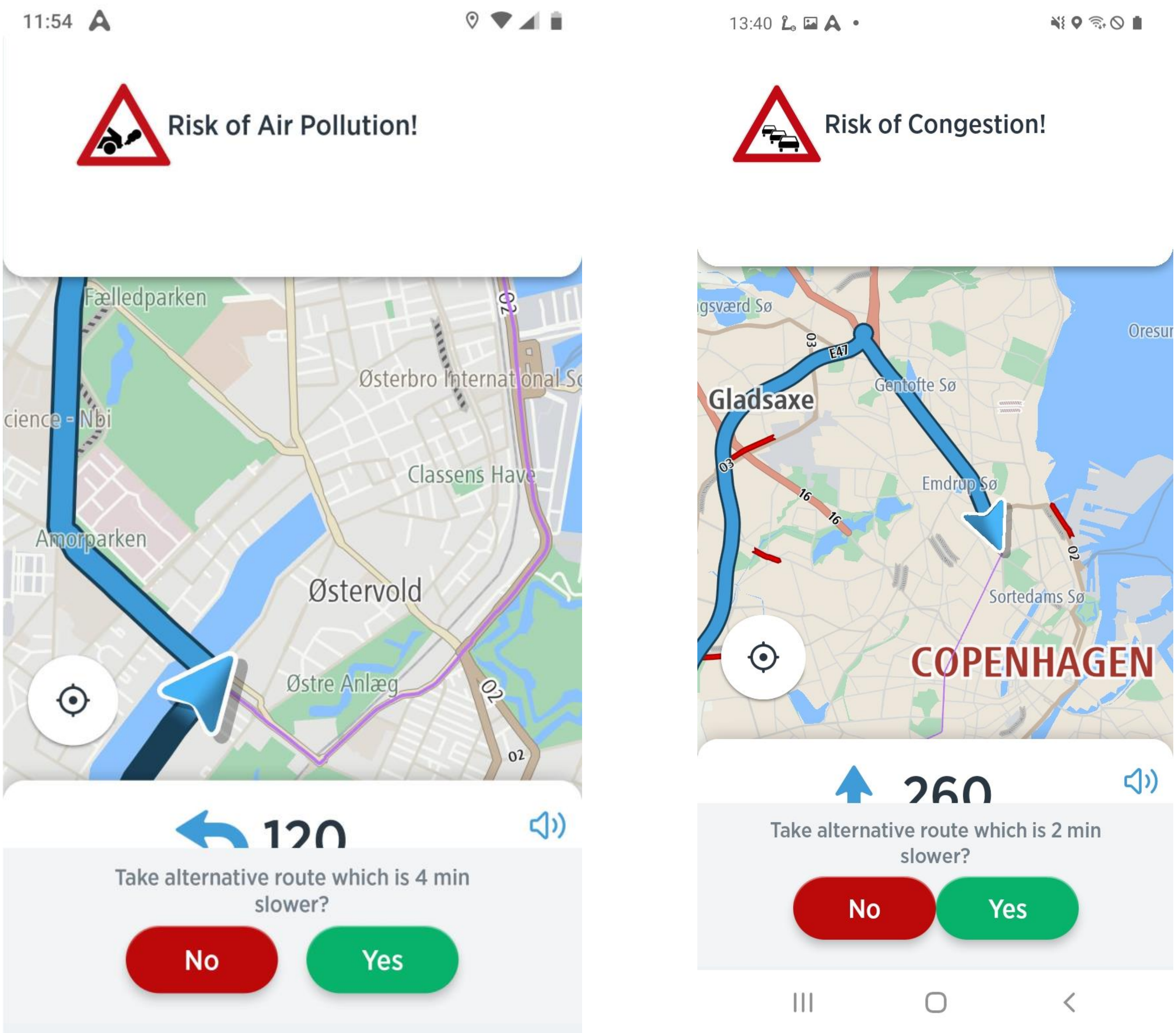


FIGURE 6 SCREENSHOTS FROM APP TOMTOM - ONTF & QOE

3. INFORMATION ARCHITECTURE – ONTF & QOE

3.1 Data Flow Diagram (Sequence diagram)

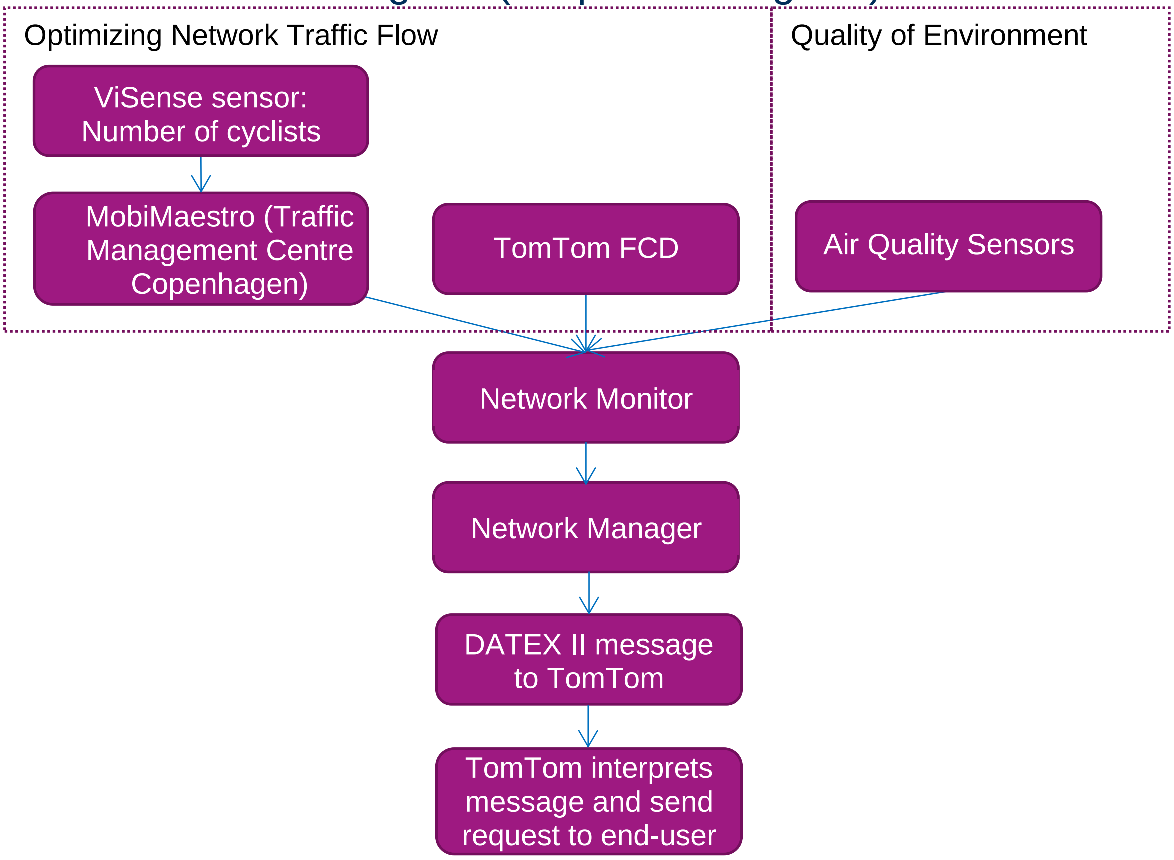


FIGURE 7 - DATA FLOW DIAGRAM ONTF & QOE

3.2 Information Architecture

The information architecture (IA) is an elaboration of the sequence diagram (see 2.1). It describes the processes and interactions between processes. The processes are functional and general conducted by one stakeholder as an internal process. A process receives and collects data, enriches the data and produces information as a product. Information is sent via protocols to other processes in the architecture.

Step 1: Import ViSense sensor data into MobiMaestro

There are eighteen ViSense sensors in Copenhagen which count cyclists. The data of six of them are used for ONTF. These six have been selected as they intersect on the car and cyclist network. The sensor data is imported in the traffic management platform MobiMaestro of the traffic management centre of Copenhagen.

Step 2a: Send trigger to Network Monitor that number of cyclists has exceeded threshold

MobiMaestro has been configured that per sensor a threshold has been set what an acceptable number of cyclists is before it becomes too busy. If the number of cyclists is above the threshold a trigger is sent to the Network Monitor.

Step 2b: Network Monitor imports FCD from TomTom

The Network Monitor imports the FCD from TomTom for the Copenhagen network.

Step 2c: Import air quality data by the Network Monitor

The University of Aarhus makes air quality data available based on two air quality sensors installed in Copenhagen. That data is imported by the Network Monitor.

Step 3: Network Monitor transfers the data to the Network Manager

The Network Monitor gathers all the relevant data and sends it through to the Network Manager

Step 4: Network Manager produces a problem state and acts on it

Based on the input of the Network Monitor the Network Manager calculates the Level of Service (LoS) for each defined link in the network. The Level of Service is a value which provides insights in the traffic situation on that specific link from free flow to a severe traffic jam. Taken the LoS into account the Network Manager acts if the LoS goes below the predefined threshold. Then it looks which measures can be applied to improve the traffic situation, taken not only into account the traffic situation on that specific link, but also the traffic situation on the other links that the measure has an effect on. The measures are available in the toolbox. In the toolbox the available measures are recorded and the toolbox is used as an input for the Network Manager. The measures are based on the Network Vision document of the city of Copenhagen.

If the predefined threshold for number of cyclists at a certain sensor is reached then this is taken into account by the Network Manager and will send out a TMex (DATEX II) message to TomTom to avoid that specific link.

The same as above holds for the air quality sensors, the only difference is that then a message is sent to TomTom for a specific area and not a link.

Step 5: Network Manager sends a DATEX II message to TomTom

When the Network Manager has decided which measure(s) to take then it sends a DATEX II (TMex) message to TomTom which specifies which links or areas to avoid.

Step 6: TomTom interprets message and send request to end-user

TomTom interprets the message and decides if it incorporates the service request, if so, it adds the condition to the specified link/area. It then sends a message to their users in their app with the reason to avoid a certain part of the city and offers them an alternative route for this. It is up to the end user if they accept this alternative route or not.

4. SYSTEM ARCHITECTURE – ONTF & QOE

4.1 System overview

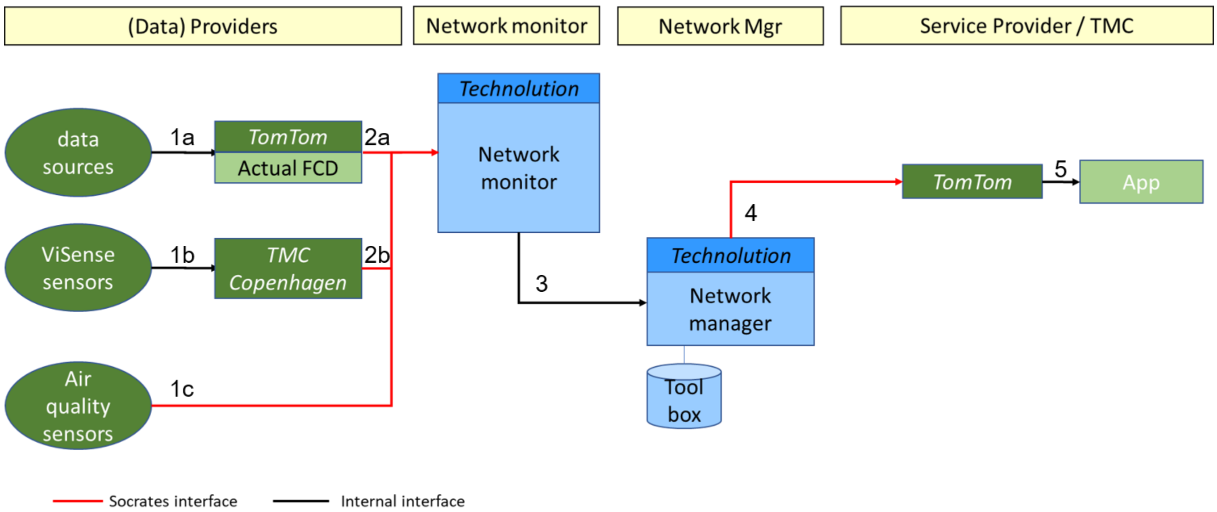


FIGURE 8 - SYSTEM OVERVIEW ONTF & QOE

4.2 Interfaces

This section contains detailed information about the interfaces and the information exchanged via these interfaces.

1a. Data sources to TomTom

This is a proprietary interface from Data source to Data provider, used internally by the Data provider. It is not described here.

1b.ViSense sensor data to MobiMaestro

ViSense offers an HTTP API to which MobiMaestro of the traffic management center of Copenhagen connects to. The data is sent real time and the format of the data is JSON and MobiMaestro processes it.

1c. Air quality data to Network Monitor

An API has been set up to extract the data from the air quality sensor and makes the data available in JSON format. The air quality data is updated every hour.

2a. TomTom to Network Monitor

Intermediate Service using Google Protocol Buffers (Protobuf). The API is available using HTTP GET and data format is defined in a Protobuf format. The following information is shared via this interface with OpenLR location referencing:

- Average speed
- Confidence
- Relative speed

- Travel Time

2b. MobiMaestro to Network Monitor

A DVM-Exchange connection has been set up between MobiMaestro Copenhagen and the Network Monitor. A DVM-Exchange request is sent when the threshold of cyclists has been exceeded. This is a real time connection.

3. Network Monitor & Network Manager

Internal connection, both within the same system at Technolution.

4. Network Manager to TomTom

DATEX II (TMex) message

Message:	Service Request
Protocol:	DATEX II
Frequency:	Whenever necessary
Related TMex dataset:	TMPlan exchange

Message information		
Name	Type	Definition
id	String	Service request ID
situationRecordCreationTime	String	Start of the situation
overallStartTime	String	Start time of the service request
overallEndTime	String	End time of the service request
causeType	Classification	The cause the service request is sent out: The following causes can be given: - abnormalTraffic, poorEnvironment, vulnerableRoadUsers
openLrLinearAsBinary	OpenLR	OpenLR string of stretch of road used for abnormalTraffic and vulnerableRoadUsers (ONTF)
openLrAreaAsBinary	OpenLR	OpenLR string of area used for poorEnvironment (QoE)
roadOrCarriagewayOrLaneManagementType	String	Action required by receiver: doNotUseSpecifiedLanesOrCarriageways

5. TomTom to app

This is a proprietary interface within TomTom.

5. INTRODUCTION - SMART DESTINATION

5.1 Use case description

The purpose is to support traffic before and after events in Parken Stadium (soccer matches) in order to optimize the experience of visitors while maintaining a high level of traffic safety and environmental responsibility.

The infrastructure around the stadium has hardly any room for parking and even dropping people off at the stadium is a challenge which often creates a traffic gridlock. This has an effect on the traffic on the roads leading to the stadium. Therefore, the city of Copenhagen would like to motivate people to take a different modality than a car to the stadium and the people that need to cross that part of city to take a different route which does not lead them through the Parken Stadium area.

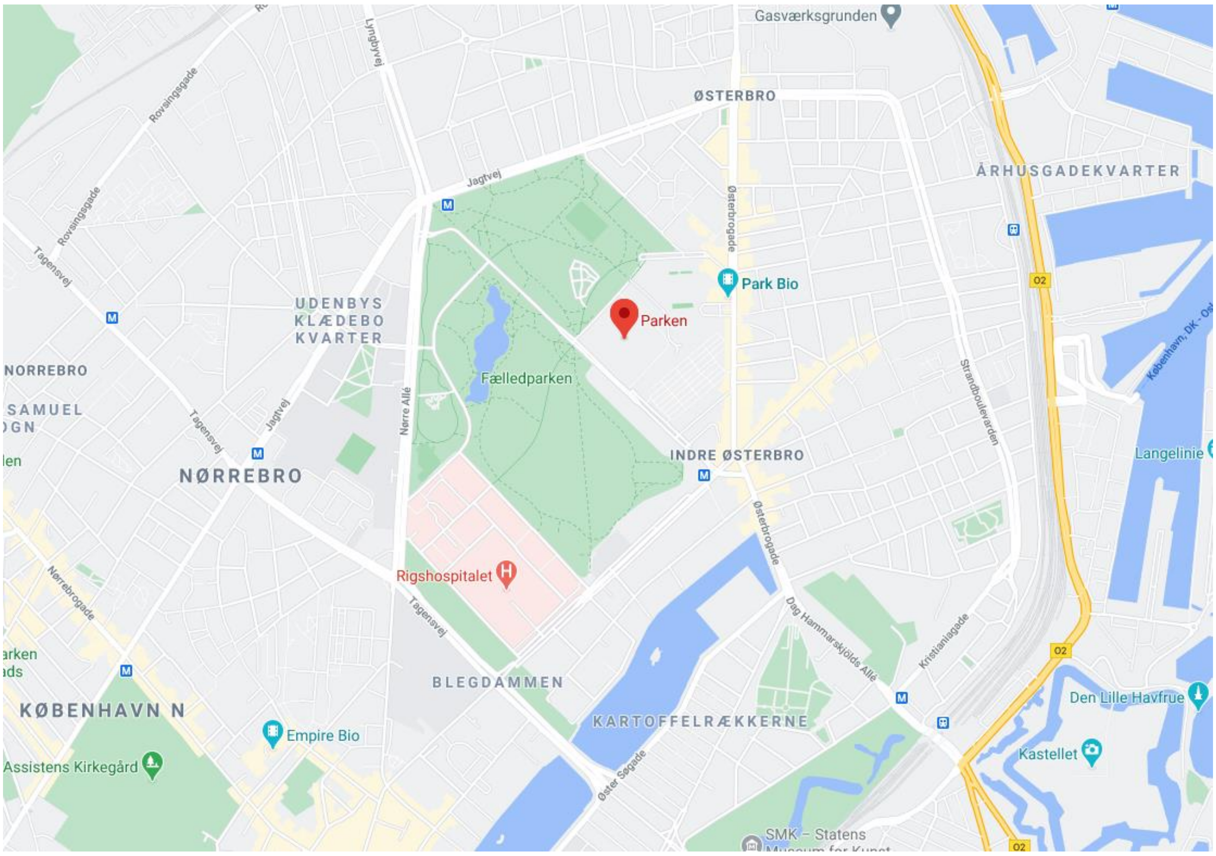


FIGURE 9 - PARKEN STADIUM

5.2 Active partners and roles

Two Socrates2.0 partners and one associated partner are active in the Smart Destination use case in Copenhagen.

FIGURE 10. ACTIVE PARTNERS AND ROLES IN THE COPENHAGEN SMART DESTINATION USE CASE

Partner	Role in use case
BrandMKRS	End user service provider
City of Copenhagen (associated partner)	Road Authority – Event liaison
Technolution	Network Manager

BrandMKRS (End user service provider)

The BrandMKRS Smart Destination service in Copenhagen aims at providing a routing advice to event visitors in the stadium area. First step is to target and approach users on social media, have them 'opt-in' to register for the service, and provide them with relevant information. Then, at the day of the event, provide the user a route to the area conform the routing request of the network manager.

City of Copenhagen (Road Authority / Event liaison)

The city of Copenhagen holds the role of road authority and the way it is set up now as a sort of event liaison. The city advises on the events that are planned and if there are special plans/circumstances for the event.

Technolution (Network Manager)

Technolution, within this use case, has the lead to interact with the city about the events. Furthermore, they are responsible that Network Manager sends the right messages at the right time to the service provider in accordance with the city.

5.3 Functional design

Changes in relation to Activity 3 – functional design

The table below contains an overview of the changes made during the further development of the Use Case in Activity 5, in relation to the Activity 3 functional design. All the things that have not changed are not documented in this table.

	SOLL	**IST**
Roles		No changes in required roles.
Intermediary	City of Copenhagen acts as intermediary	City of Copenhagen was not an intermediary. Technolution took over that role.
Actors		BrandMKRS is end user service provider
Pre-/post conditions		Due to the Corona crisis no events with a larger group of visitors/ greater audience take place since 03/2020 till at least the spring of 2021. Thus, targeting/ recruiting/ interviewing real end users was not feasible. A real piloting period could not be executed. Compensation via friendly user tests.
Sequence diagram		See changes in figure 10

5.4 Generic Description of end user service

To keep traffic flowing as much as possible around events, people are encouraged to use public transport. Of course, there always will be people that use cars to get to the event. However, there is only limited room for cars around the event location (Parken Stadium) and this will cause traffic. To help guide visitors of events that take public transport or their car to the event BrandMKRS offers their service.

BrandMKRS offers a service where they reach out to users via social media (such as Twitter, Facebook, Instagram, Snapchat, TikTok) or online media (such as Google Maps, Google Search, websites with ads) or social messaging applications (such as WhatsApp, Facetime or SMS). User recruitment is done via online campaigns that may include geofences to target audiences based on specific locations. People should register as 'SOCRATES user' which entails that BrandMKRS can communicate with them via the agreed channels. The information campaign typically follows a communication strategy (at what time, what message, to what user group) but messages can also be sent real time. In general, BrandMKRS distinguishes between pre-trip, on-trip and post-trip communication.

In the SOCRATES pilot Copenhagen, due to the absence of real events no user community was formed. So, no messages were sent out via the different channels (social or online media or messaging apps) to real users. During the functional chain test, of the 'Copenhagen Traffic Management Centre' messages were sent (via DVM-X) real time by the BrandMKRS Copenhagen service to test users via WhatsApp or SMS. The nature of the messages could differ between: modality ("please use public transport"), parking ("if you go by car, then best parking is", Kiss-Ride ("preferred drop-off / pick-up locations").

The first message based on this service is sent to the end user 24 hours before the event takes place to give the visitors enough time to prepare or change their travel plans. The second message is sent eight hours before the event and then respectively three hours before the event, one and a half hour and the last one is at the end of the event. The closer one is to the start of the event the more specific the information gets. The timing and the content of the message can easily be altered and is something that needs to evaluated once it is used at actual events.

An example of parking advice is shown on the next page:

Screenshots of end user service BrandMKRS

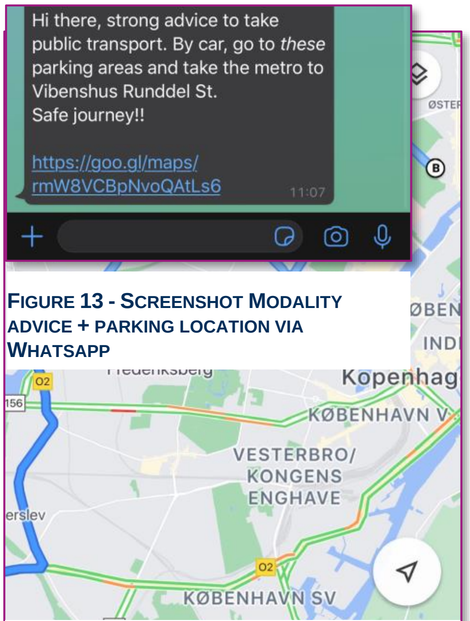


Figure 13 - Screenshot Modality advice + parking location via WhatsApp

Figure 14 - Screenshot Whole route

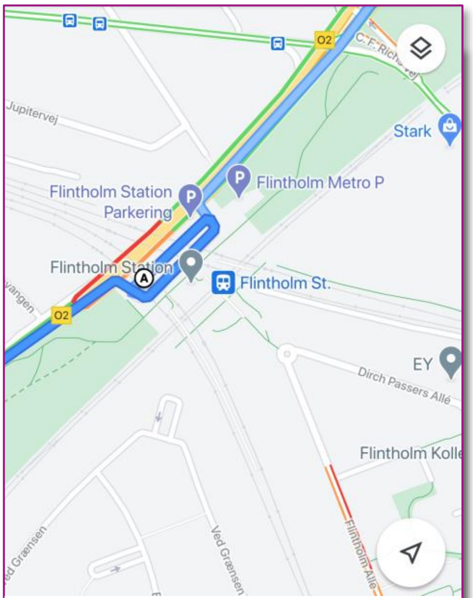


Figure 12 - Screenshot detail of parking at metro

6. INFORMATION ARCHITECTURE – SMART DESTINATION

6.1 Data Flow Diagram (Sequence diagram)

The events where the city of Copenhagen expects a lot of people who do not visit the event location regularly and would like to deploy the service of BrandMKRS, are being communicated with Technolution and they are manually inserted into the Network Manager. The message that the end-users will get is dependent on how they registered for the service. If they registered as an event visitor or someone who lives or works close to the event location.

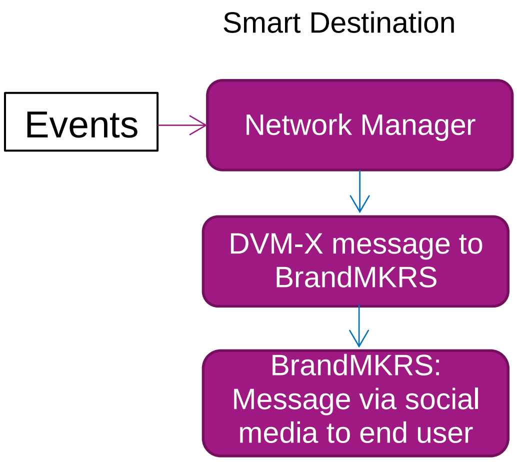


FIGURE 15 - DATA FLOW DIAGRAM SMART DESTINATION

6.2 Information Architecture

The information architecture (IA) is an elaboration of the sequence diagram (see 2.1). It describes the processes and interactions between processes. The processes are functional and general conducted by one stakeholder as an internal process. A process receives and collects data, enriches the data and produces information as a product. Information is sent via protocols to other processes in the architecture.

Step 1: Insert events into Network Manager

The events that are going to take place need to be manually inserted into the Network Manager including the time and date of the event.

Step 2: Send message from Network Manager to BrandMKRS

In the Network Manager there is a calendar function which automatically sends out messages to BrandMKRS based on the pre-defined script. In the script the times and dates are documented. The messages are sent out via the DVM-Exchange protocol. Technolution and BrandMKRS created a pre-defined service-table with all possible DVM-Exchange messages before an event, so BrandMKRS was aware of the DVM-Exchange messages' meaning and how to inform their end users.

Step 3: Send message from BrandMKRS to end user

BrandMKRS will sent out their pre-defined messages to their registered users via social media almost immediately after they receive the message from the Network Manager.

7. SYSTEM ARCHITECTURE - SMART DESTINATION

7.1 System overview

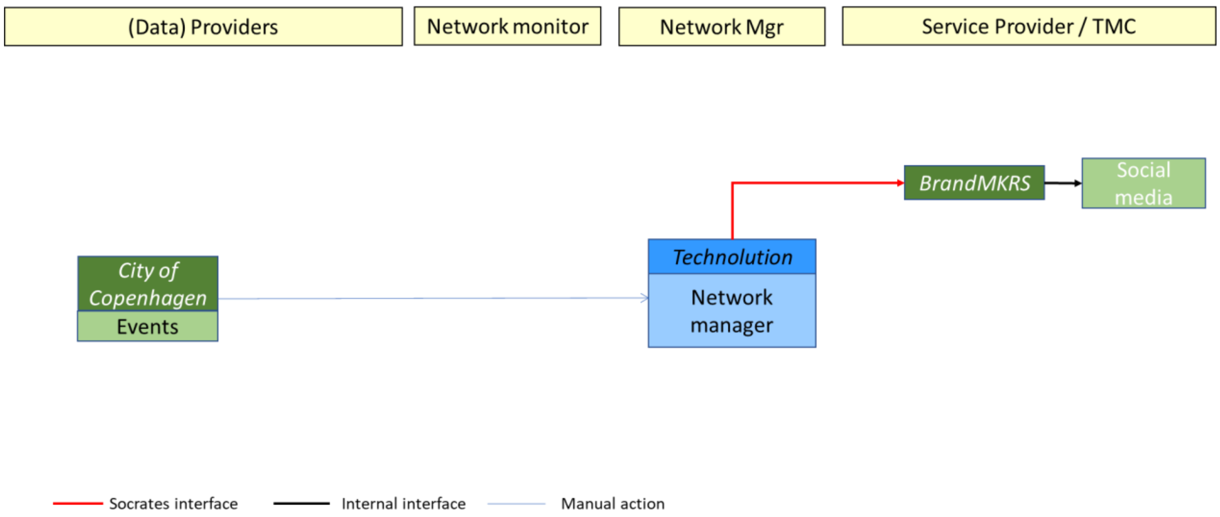


FIGURE 16 - SYSTEM OVERVIEW SMART DESTINATION

7.2 Interfaces

Events

The events are shared by the city of Copenhagen with Technolution and are manually inserted in the graphical interface of the Network Manager.

Network Manager & BrandMKRS

An DVM-Exchange connection has been set up between the Network Manager and BrandMKRS. A DVM-Exchange request is sent when the (time-based) trigger is activated in the Network Manager. The information in the message itself is limited to a pre-defined code part of the service-table that was agreed on between Technolution and BrandMKRS so that is known what is meant with the message. This is a real time connection.

BrandMKRS & Social media

BrandMKRS sends a message via social media to their users. The user can choose via which platform they want to receive the information.

8. OPERATIONAL PERIOD

8.1 Impact of COVID-19

COVID-19 had a severe impact on the functional piloting of the services developed to test the use cases.

For the ONTF and QoE use case, traffic was nowhere near normal intensities. This resulted in far less congestion and pollution than before the Corona period. This, in turn, diminished the cause for necessity of alternative routes, since the preferred routes of users were not affected by congestion and users could take those routes free-flow. This led to far less enthusiasm for the recruitment of end users for this use case than anticipated.

For the Smart Destination use case, the impact was even worse, since no events were organised, leaving the use case with no practical circumstances to test the benefits for event public.

Nevertheless, the organisational and technical set-up and execution of all use cases were tested and could be evaluated. This was also the case for the functional evaluation of the ONTF and QoE use case. Additionally, a technical chain test for the Smart Destination use case was also executed.